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A NUMERICAL STUDY OF THE NANOSECOND AND SUBNANOSECOND PERFORMAN--ETC(U)
APR 81 R H LEHMBERG, J M MCMAHON
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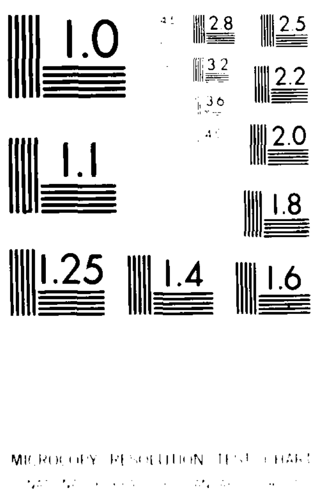
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A numerical study is conducted to examine the performance potential of the GEKKO XII-Module, a phosphate glass laser system currently under development at Osaka University. The study shows that with appropriate modifications, this system should produce peak powers up to 3.6 TW/beam in a 50 psec pulse, and 2-2.5 kJ/beam in a 1 nsec pulse. The similarity be-between the GEKKO XII-Module and Shiva beam line configurations suggests that a phosphate glass retrofit of Shiva could produce nanosecond pulse energies up to 50kJ.

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CONTENTS

A NUMERICAL STUDY OF THE NANOSECOND AND SUBNANOSECOND PERFORMANCE OF GEKKO XII-MODULE

1. Introduction

The GEKKO XII laser at Osaka University will ultimately be a twelve beam, 20 kJ, 40 TW system design for laser fusion studies.[1] Recently, Osaka University scientists reported on the short pulse performance of the prototype module of this laser, which is called GEKKO XII-Module, quoting an output of up to 3.4 TW/beam before beam breakup was encountered.[2,3] The GEKKO XII-Module performance is of especial interest to the U.S. ICF program because the components are similar to those in the Shiva laser at Lawrence Livermore National Laboratory[4] - with the significant difference that LGH-7 phosphate laser glass is used rather than a silicate laser glass. The performance of this laser should therefore provide data on the performance to be expected from Shiva when it is retrofitted with phosphate glass as part of the Nova upgrade.

In this report, we summarize the results of a numerical investigation of the expected performance of the GEKKO XII-Module laser at nanosecond and subnanosecond pulsewidths. The configuration and amplifier (small signal) performance were as specified by the Osaka laser group.[1] The large signal behavior was calculated using the NRL laser amplifier code KARL, plus a spatial filter transmission algorithm similar to that used to model the present performance of Shiva. The Osaka claim of 3.4 TW/beam in a short pulse is reasonable; however, the reported configuration is not a particularly good choice for nanosecond operation, as coating damage would be expected at slightly above 1000J/beam. Various reconfiguration

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choices and passive optics modifications were examined to alleviate this problem, and with a reasonably optimum strategy, outputs of 1800-2000J/beam appear possible. Addition of a second twenty cm amplifier to each beam would raise the output to about 2500J/beam.

2. GEKKO XII-Module Configuration

The GEKKO XII-Module consists of various preamplifiers followed by a 5-10 cm beam telescope/spatial filter; a 10 cm disc amplifier; a Faraday rotator package; another 10 cm disc amplifier; a 10-15 cm spatial filter telescope; a 15 cm disc amplifier; a Faraday Rotator package; a 15-20 cm spatial filter; a 20 cm disc amplifier; a Faraday Rotator package.[1] A final lens was assumed at the end of the chain as an initial element of a relay telescope/beam expander before the target optics. Figure 1 is the schematic diagram, and Figure 2 shows a recent picture of the installation, with the oscillator and preamplifier section in the center, and the first test arm on the right hand side.

In the computer studies, the performance of components reported by the Osaka group was used where the information was available;[1] where such information was not available, the specifications of the equivalent Shiva component were used.[4] Exact component values are tabulated in the computer printouts included with this report. It should be noted that the reported gain of the 15 cm amplifier was significantly lower than the achievable value. This amplifier is less efficient because the diameter of its flashlamp circle is comparable to that of the 20 cm amplifier, in order to accomodate additional fixtures used for testing liquid edge cladding of the laser glass.[5] Table 1 shows a comparison of the amplifier gains on GEKKO XII-Module and Shiva, and the ratio of

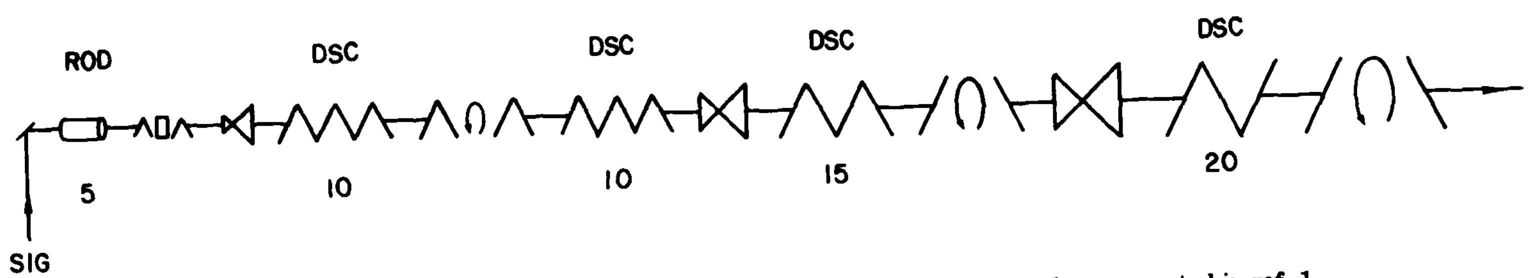

Fig. 1 — Schematic diagram of a single beam line of the Gekko XII Module, as reported in ref. 1

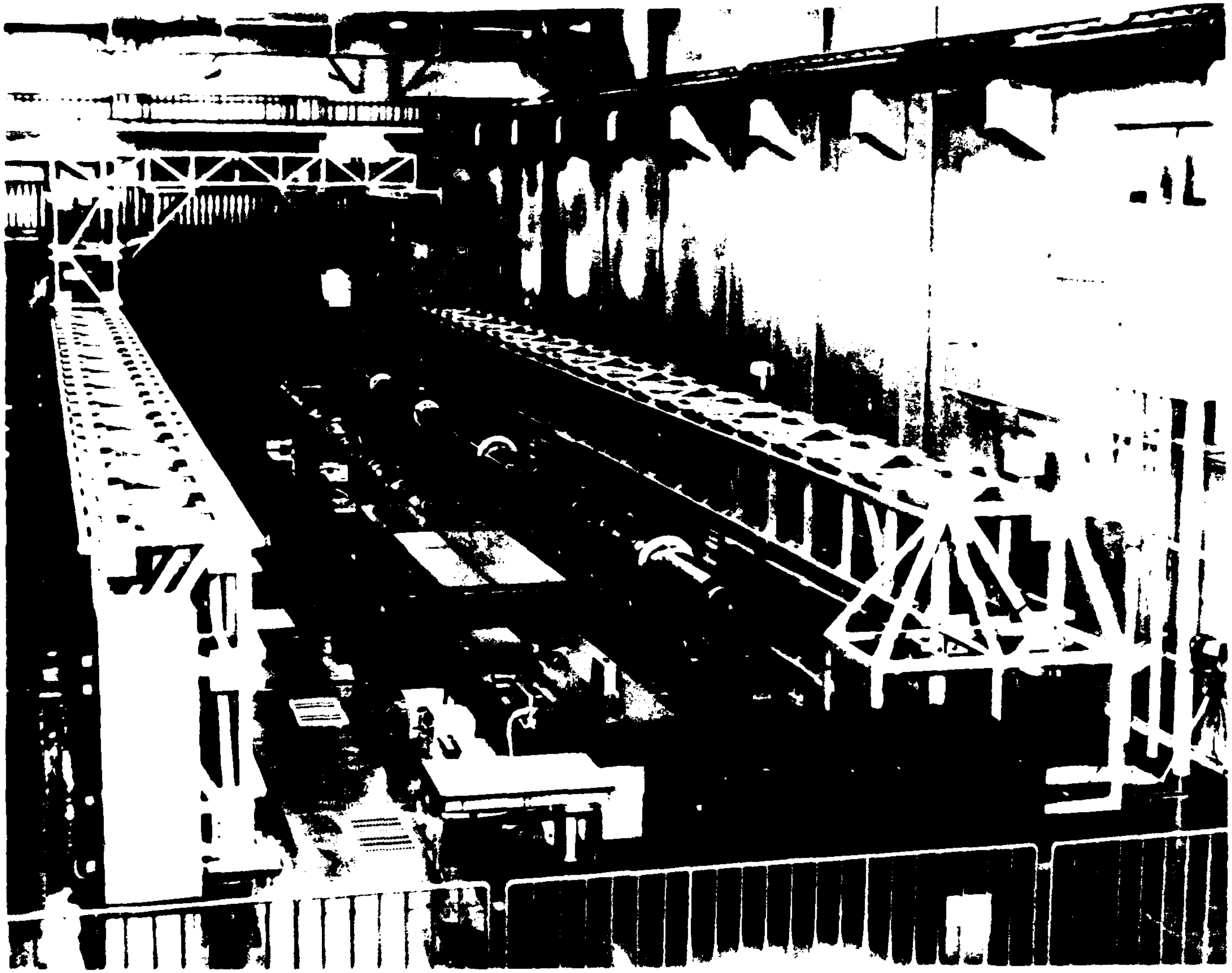

Fig. 2 Recent picture of Gekko XII, showing the oscillator and preamplifier section in the center, and the first test arm on the right hand side.

Table I: Comparison of Shiva and Gekko XII Disc Amplifiers

Aperture (cm)	Shiva Gain	Gekko Gain	Ratio of Gain Coefficients
10	3.67	8.5	1.65
15	2.61	3.4	1.27
20	1.95	3.2	1.73

the gain coefficients for the two systems. A gain of 3.4 was reported for this amplifier, but a gain of at least 4.88 should be possible if one compares, for example, the 10 cm amplifiers. In computing the Gekko XII short pulse performance we used the reported gain for this amplifier, but in examining nanosecond operation we looked at the performance both with the reported gain and with what should be the achievable gain for the 15 cm disk module.

3. Computer Code

The numerical calculations were carried out using the KARL code[6] with twenty radial zones and fifty time steps for each optical component. For the pulse incident at the 50 mm rod, the temporal shape was assumed to be Gaussian, while the radial profile was a hyper-Gaussian $\exp\{-(r/r_o)^{12}\}$ with $r_o = 20$ mm.

The laser amplifiers were modelled by the Avizones-Grotbeck rate equations[7] with a lower level relaxation term:

$$\partial I/\partial z = \alpha_o(W_2 - \eta W_1)\, I - \gamma I$$

$$\partial W_2/\partial t = -(W_2 - \eta W_1)\, I/(1+\eta)F_s, \qquad W_2(-\infty) = 1$$

$$\partial W_1/\partial t = -\,\partial W_2/\partial t - W_1/T_1\,, \qquad W_1(-\infty) = 0$$

Here, I is the intensity, W_2 $\{W_1\}$ is the normalized upper {lower} level population, η is the upper/lower level degeneracy ratio ($\eta = 1$ in all of the runs shown here), F_s is the short pulse saturation flux, and T_1 is the lower level relaxation time. The initial gain coefficient α_0 is found from the relation $\alpha_0 = \gamma + L^{-1} \ln G_o$, where G_o is the measured small signal gain of the amplifier, L is the active path length, and γ

is the loss coefficient, which models the estimated 1% loss per disc. For most of the runs shown here, we chose F_s = 2.42 J/cm^2 [8] with T_1 = 3 nsec; in Tables VIII and X, however, we used the more optimistic value F_S = 3.6 J/cm^2 (with T_1 = 1000 nsec). In test problems where $\gamma \rightarrow 0$ and $T_1 >> t_{(pulse)}$, the numerical solutions were found to agree with the Frantz-Nodvik theory to an accuracy better than 1%, even under heavily saturated conditions.

Quantities computed after each component include total power and energy, incremented and total B integrals, peak to average intensity ratios, maximum intensity, and energy density. These are defined in more detail in Table 11. For the nanosecond cases spatial filter transmission was assumed to be unity, as the largest ΔB generated between successive spatial filters was 1.8 in all the cases studied here. For the short pulse cases a LLNL algorithm was used, as discussed below.

4. Short Pulse Test Case

The code was operated to predict GEKKO XII-Module short pulse (50 ps) performance. The spatial filter transmission algorithm used, T(B) = $\{1 + 2 \times 10^{-4} \exp (2\Delta B)\}^{-1}$, was obtained from W.F. Hagen of LLNL, and is the one in use for Shiva and Nova calculations. The generation of low spatial frequency ripples by pinhole truncation and low frequency self-focusing noise amplification was not explicitly included, but was modelled by restricting the spatial profile to have a peak/average intensity ratio greater than 1.6 to 1.

Table III shows a computer listing for the short pulse performance of the original design reported in Ref. 1. Here, a spatial filter was also added at the output of the reported configuration, in order to

Table II: Glossary of Parameters Appearing in the Computer Listings

Optical component (e.g. DSC = Disc amplifier)	Beam aperture (cm)	Glass thickness (cm)	Small signal gain or transmission	Incidence angle (deg)	Linear refractive index	Nonlinear refractive index (10^{13} x esu)	Peak power (GW)	Total energy (J)	Peak on-axis B increment (rad)	Peak on-axis net B integral (rad)	On-axis flux/average flux	Peak on-axis intensity (GW/cm^2)	On-axis flux (J/cm^2)
	APER	THCK	GLIN	ANGL	NO	N2	PMAX	EQUT	BIMX	BTMX	P/AV	IMAX	FLUX
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
DSC	10.00	6x 2.43	8.50	56.38	1.504	1.050	.927E02	.464E01	0.165	0.575	1.680	.198E01	.992E01

(ALD = 2.50, FS = 2.42, ETA = 1.00, TI = 3.00)

Lower level relaxation time (nsec)

Upper level degeneracy/lower level degeneracy

Short pulse saturation flux $h\nu/2\sigma$ (J/cm^2)

Gain coefficient x major diameter

highlight the problem with this design. Immediately after the 20 cm disc module, over 4TW/beam of focusable power is available (incremental B = 1.95). However, the Faraday rotator package (POL-ROT-POL) immediately following has a very large additional B increment (1.88), and one would expect that much of the power through the final lens would not be focusable. The focusable output is shown on the bottom line of Table III, and the corresponding spatial and temporal profiles are shown in Figure 3. The center of the pulse has clearly been "blown out", resulting in a focusable power of only 2.4TW/beam. It should be noted that the 3.4 TW performance reported in Ref. 3 was measured without the final Faraday rotator package.

Fortunately, this package can be retained in the system without a significant loss of performance. Interchanging the location of Faraday Rotator modules and disk modules in both the 15 and 20 cm sections, one obtains a focusable power of 3.6 TW/beam as shown in Table IV and Figure 4. The reconfigured system has adequate isolation in that a 60% back-reflection would still produce only 1.5J/cm^2 on the 20 cm Faraday rotator.

5. Nanosecond Pulse Performance

The expected nanosecond performance of the reported configuration is summarized in Table V. This design is limited by damage to the AR coated input lens of the 10-15 cm telescope at an output of about 1000 J/beam. This is essentially the same problem as encountered with Shiva at long pulses; i.e., even with the added gain in the phosphate disc amplifiers, the laser is still optimized for short pulses. In this calculation we used a saturation flux of 2.42 J/cm^2. Use of a higher saturation flux such as 3.6J/cm^2 would increase the output slightly (ie. ~10%).

TABLE III: SHORT (50 psec) PULSE PERFORMANCE OF REPORTED GEKKO SYSTEM

	APER	THCK	GLIN	ANGL	NO	N2	PMAX	EOUT	BINX	BTNX	P/AV	IMAX	FLUX
SIG	5.00						.100E 01	.500E-01	0.000	0.000	1.684	.858E-01	.429E-02
ROD	5.00	1X30.00	13.40	0.00	1.504	1.050	.133E 02	.663E 00	0.213	0.213	1.682	.114E 01	.568E-01
	(ALD= 0.43,		FS= 2.42,	ETA= 1.00,		TI= 3.00)							
POL	5.00	2X 0.80	0.94	56.43	1.507	1.240	.125E 02	.624E 00	0.029	0.242	1.682	.107E 01	.534E-01
PSC	5.00	1X 7.03	0.96	0.00	1.500	1.000	.120E 02	.599E 00	0.122	0.364	1.682	.103E 01	.513E-01
POL	5.00	2X 0.80	0.94	56.43	1.507	1.243	.113E 02	.563E 00	0.026	0.391	1.682	.964E 00	.482E-01
LNS	5.00	1X 0.80	0.99	0.00	1.507	1.240	.111E 02	.557E 00	0.016	0.406	1.682	.955E 00	.477E-01
SPF	10.00	1X 0.03	1.00	0.00	0.000	0.000	.111E 02	.557E 00	0.000	0.406	1.682	.239E 00	.119E-01
LNS	10.00	1X 0.83	0.99	0.00	1.507	1.240	.110E 02	.551E 00	0.004	0.410	1.682	.236E 00	.118E-01
OSC	10.00	6X 2.43	8.50	56.38	1.504	1.050	.927E 02	.464E 01	0.165	0.575	1.680	.198E 01	.992E-01
	(ALD= 2.50,		FS= 2.42,	ETA= 1.00,		TI= 3.00)							
POL	10.00	2X 0.80	0.94	56.43	1.507	1.240	.871E 02	.436E 01	0.050	0.626	1.680	.186E 01	.932E-01
ROT	10.00	1X 0.80	0.98	0.00	1.673	2.100	.854E 02	.427E 01	0.046	0.672	1.680	.183E 01	.913E-01
POL	10.00	2X 0.80	0.94	56.43	1.507	1.240	.803E 02	.401E 01	0.046	0.718	1.680	.172E 01	.859E-01
OSC	10.00	6X 2.49	8.50	56.38	1.504	1.050	.631E 03	.317E 02	1.155	1.873	1.665	.134E 02	.671E 00
	(ALD= 2.50,		FS= 2.42,	ETA= 1.00,		TI= 3.00)							
LNS	10.00	1X 0.80	0.99	0.00	1.507	1.240	.625E 03	.313E 02	0.219	2.092	1.665	.132E 02	.664E 00
SPF	15.00	1X 0.00	1.00	0.00	0.000	0.000	.622E 03	.313E 02	0.000	2.092	1.664	.585E 01	.294E 00
LNS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.616E 03	.309E 02	0.132	2.224	1.664	.579E 01	.291E 00
OSC	15.00	4X 3.00	3.40	56.38	1.504	1.050	.193E 04	.971E 02	1.808	4.032	1.649	.180E 02	.906E 00
	(ALD= 2.55,		FS= 2.42,	ETA= 1.00,		TI= 3.00)							
POL	15.00	1X 1.10	0.94	56.43	1.507	1.240	.181E 04	.913E 02	0.314	4.344	1.649	.169E 02	.852E 00
ROT	15.00	1X 1.10	0.98	0.00	1.673	2.100	.177E 04	.894E 02	0.578	4.918	1.649	.166E 02	.835E 00
POL	15.00	1X 1.10	0.94	56.43	1.507	1.240	.167E 04	.841E 02	0.290	5.206	1.649	.156E 02	.785E 00
LNS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.165E 04	.832E 02	0.351	5.556	1.649	.154E 02	.777E 00
SPF	20.00	1X 0.00	1.00	0.00	0.000	0.000	.144E 04	.789E 02	0.000	5.556	1.617	.722E 01	.406E 00
LNS	20.00	1X 1.50	0.99	0.00	1.507	1.240	.143E 04	.781E 02	0.222	5.774	1.617	.715E 01	.402E 00
OSC	20.00	3X 3.20	3.20	56.38	1.504	1.050	.417E 04	.226E 03	1.732	7.459	1.601	.210E 02	.115E 01
	(ALD= 3.96,		FS= 2.42,	ETA= 1.00,		TI= 3.00)							
POL	20.00	1X 1.50	0.94	56.43	1.507	1.240	.392E 04	.213E 03	0.500	7.937	1.601	.197E 02	.108E 01
ROT	20.00	1X 1.50	0.98	0.00	1.673	2.100	.384E 04	.209E 03	0.920	8.836	1.601	.193E 02	.106E 01
POL	20.00	1X 1.50	0.94	56.43	1.507	1.240	.361E 04	.196E 03	0.461	9.287	1.601	.182E 02	.999E 00
LNS	20.00	1X 1.50	0.99	0.00	1.507	1.240	.357E 04	.194E 03	0.558	9.833	1.601	.190E 02	.989E 00
SPF	20.00	1X 0.00	1.00	0.00	0.000	0.000	.238E 04	.151E 03	0.000	9.833	1.490	.116E 02	.714E 00

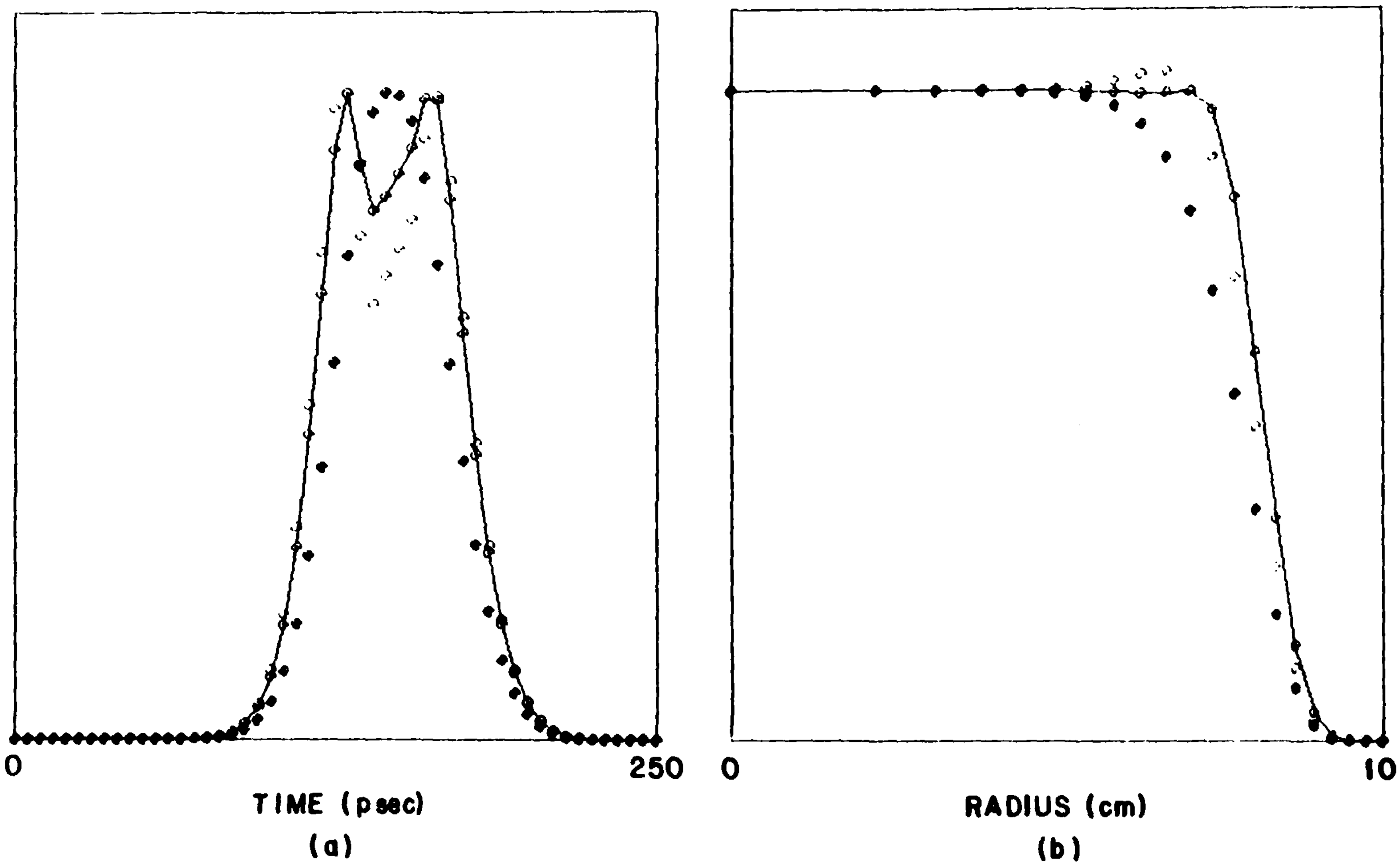

Fig. 3 — Temporal (3a) and spatial (3b) profiles and the output of the reported configuration with a 50 psec input pulse. In (3a): ~~oooooo~~ = Power, oooooo = Intensity on axis, and ●●●●●● = Total nonlinear phase distortion (B integral) on axis. In (3b): ~~oooooo~~ = Flux, oooooo = Intensity at the time of peak power, and ●●●●●● = Total nonlinear phase distortion at the time of peak power.

TABLE IV: SHORT (50 psec) PERFORMANCE OF RECONFIGURED SYSTEM

TE= 0.050 WL= 1.053

	APER	THCK	GLIN	ANGL	NO	N2	PMAX	EOUT	BIRX	BTRX	P/AV	IMAX	FLUX
SIG	5.00						.100E 01	.500E-01	0.000	0.000	1.684	.058E-01	.429E-02
ROD	5.00	1X30.00	13.40	0.00	1.504	1.050	.133E 02	.663E 00	0.213	0.213	1.682	.114E 01	.560E-01
	(ALD= 0.43,		FS= 2.42,	ETA= 1.00,		T1= 3.00)							
POL	5.06	2X 0.00	0.94	56.43	1.507	1.240	.125E 02	.624E 00	0.029	0.242	1.682	.107E 01	.534E-01
PBC	5.00	1X 7.03	0.96	0.00	1.500	1.000	.120E 02	.599E 00	0.122	0.364	1.682	.103E 01	.513E-01
POL	5.00	2X 0.00	0.94	56.43	1.507	1.240	.113E 02	.563E 00	0.026	0.391	1.682	.964E 00	.482E-01
LHS	5.00	1X 0.03	0.99	0.00	1.507	1.240	.111E 02	.557E 00	0.016	0.406	1.682	.955E 00	.477E-01
SPF	10.00	1X 0.03	1.00	0.00	0.000	0.000	.111E 02	.557E 00	0.000	0.406	1.682	.239E 00	.119E-01
LHS	10.00	1X 0.00	0.99	0.00	1.507	1.240	.110E 02	.551E 00	0.004	0.410	1.682	.236E 00	.118E-01
OSC	10.00	6X 2.40	8.50	56.30	1.504	1.050	.927E 02	.464E 01	0.165	0.575	1.680	.198E 01	.992E-01
	(ALD= 2.50,		FS= 2.42,	ETA= 1.00,		T1= 3.00)							
POL	10.00	2X 0.00	0.94	56.43	1.507	1.240	.871E 02	.436E 01	0.050	0.626	1.680	.186E 01	.932E-01
ROT	10.00	1X 0.00	0.98	0.00	1.673	2.100	.854E 02	.427E 01	0.046	0.672	1.680	.183E 01	.913E-01
POL	10.00	2X 0.03	0.94	56.43	1.507	1.240	.803E 02	.401E 01	0.046	0.718	1.680	.172E 01	.859E-01
OSC	10.00	6X 2.40	8.50	56.30	1.504	1.050	.631E 03	.317E 02	1.155	1.873	1.665	.134E 02	.671E 00
	(ALD= 2.50,		FS= 2.42,	ETA= 1.00,		T1= 3.00)							
LHS	10.00	1X 0.00	0.99	0.00	1.507	1.240	.625E 03	.313E 02	0.219	2.092	1.665	.132E 02	.664E 00
SPF	15.00	1X 0.00	1.00	0.00	0.000	0.000	.622E 03	.313E 02	0.000	2.092	1.664	.585E 01	.294E 00
LHS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.616E 03	.309E 02	0.132	2.224	1.664	.579E 01	.291E 00
POL	15.00	1X 1.10	0.94	56.43	1.507	1.240	.579E 03	.291E 02	0.101	2.325	1.664	.544E 01	.274E 00
ROT	15.00	1X 1.10	0.98	0.00	1.673	2.100	.567E 03	.285E 02	0.186	2.511	1.664	.533E 01	.268E 00
POL	15.00	1X 1.10	0.94	56.43	1.507	1.240	.533E 03	.268E 02	0.093	2.604	1.664	.501E 01	.252E 00
OSC	15.00	4X 3.00	3.40	56.30	1.504	1.050	.160E 04	.849E 02	1.575	4.180	1.651	.157E 02	.793E 00
	(ALD= 2.55,		FS= 2.42,	ETA= 1.00,		T1= 3.00)							
LHS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.167E 04	.841E 02	0.354	4.532	1.651	.156E 02	.785E 00
SPF	20.00	1X 0.00	1.00	0.00	0.000	0.000	.163E 04	.833E 02	0.000	4.532	1.646	.854E 01	.437E 00
LHS	20.00	1X 1.50	0.99	0.00	1.507	1.240	.162E 04	.825E 02	0.262	4.793	1.646	.846E 01	.432E 00
POL	20.00	1X 1.50	0.94	56.43	1.507	1.240	.152E 04	.775E 02	0.202	4.996	1.646	.795E 01	.406E 00
ROT	20.00	1X 1.50	0.98	0.00	1.673	2.100	.149E 04	.760E 02	0.370	5.362	1.646	.779E 01	.398E 00
POL	20.00	1X 1.50	0.94	56.43	1.507	1.240	.140E 04	.714E 02	0.186	5.547	1.646	.732E 01	.374E 00
OSC	20.00	3X 3.20	3.20	56.30	1.504	1.050	.411E 04	.208E 03	1.765	7.206	1.629	.213E 02	.108E 01
	(ALD= 3.96,		FS= 2.42,	ETA= 1.00,		T1= 3.00)							
LHS	20.00	1X 1.53	0.99	0.00	1.507	1.240	.407E 04	.206E 03	0.653	7.923	1.629	.211E 02	.107E 01
SPF	20.00	1X 0.03	1.00	0.00	0.000	0.000	.358E 04	.196E 03	0.000	7.923	1.601	.178E 02	.999E 00

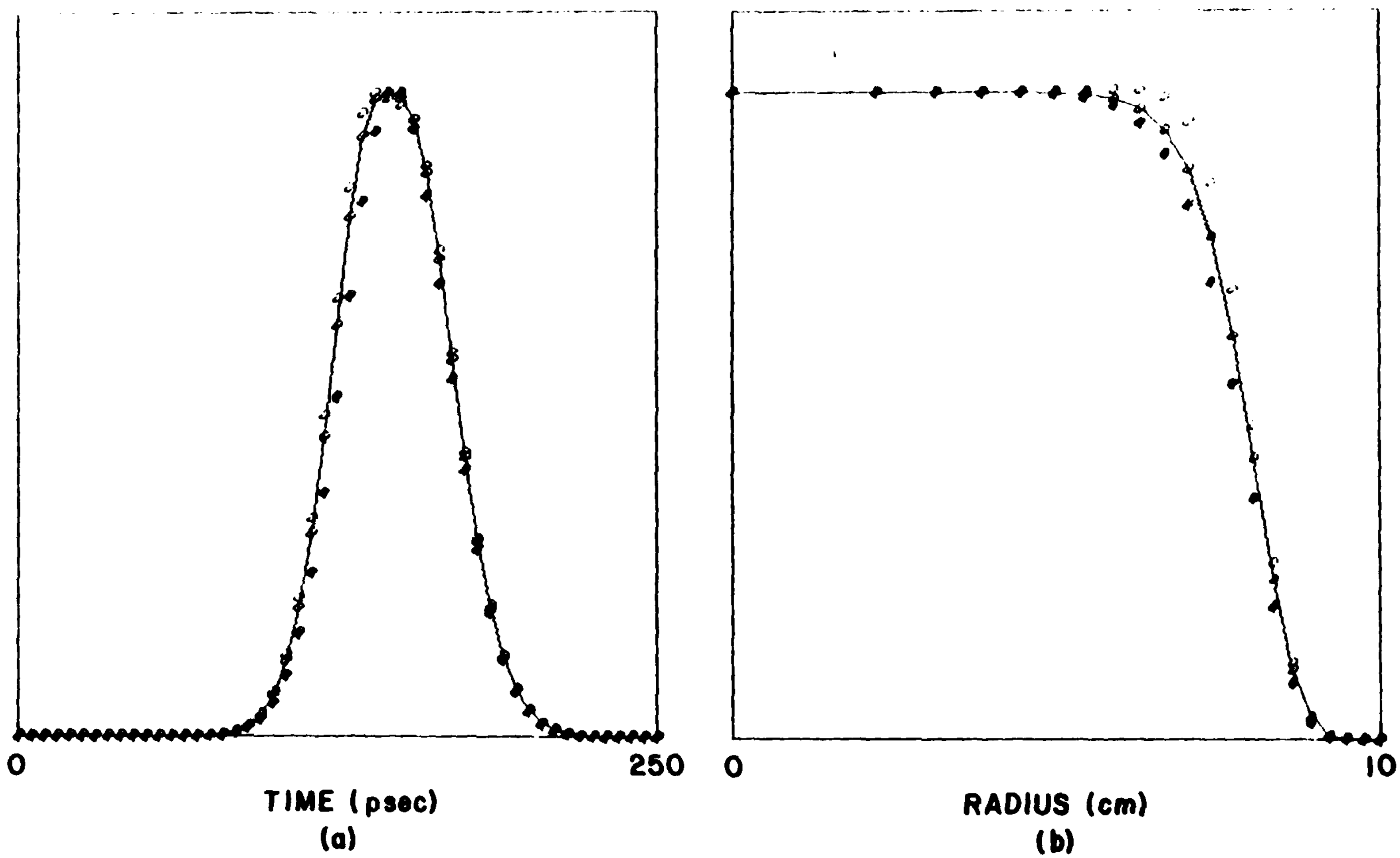

Fig. 4 — Temporal (4a) and spatial (4b) profiles at the output of the reconfigured system with a 50 *psec* input pulse. The curves have the same meaning as those in Figs. (3a, b).

TABLE V: NANOSECOND PERFORMANCE OF REPORTED GEKKO SYSTEM

TE= 1.000 nsec WL= 1.053 μ

	APER	THCK	GLIN	ANGL	N0	N2	PMAX	EOUT	BTAX	BTOT	P/AV	IMAX	FLUX
SIG	5.00						.125E 01	.125E 01	0.000	0.000	1.604	.107E 00	.107E 00
600	5.00	1X30.00	13.40	0.00	1.504	1.050	.137E 02	.130E 02	0.230	0.230	1.649	.115E 01	.116E 01
	(ALD= 0.43,	FS= 2.42,		ETA= 1.00,		TI= 3.00)							
POL	5.00	2X 0.00	0.94	56.43	1.507	1.240	.129E 02	.130E 02	0.029	0.267	1.640	.100E 01	.109E 01
POC	5.00	1X 7.00	0.96	0.00	1.580	1.000	.124E 02	.125E 02	0.124	0.390	1.640	.104E 01	.105E 01
POL	5.00	2X 0.03	0.94	56.43	1.507	1.240	.116E 02	.117E 02	0.026	0.416	1.640	.976E 00	.985E 00
LHS	5.00	1X 0.00	0.99	0.00	1.507	1.240	.115E 02	.116E 02	0.016	0.432	1.640	.966E 00	.975E 00
LHS	10.00	1X 0.00	0.99	0.00	1.507	1.240	.114E 02	.115E 02	0.004	0.436	1.640	.239E 00	.241E 00
DSC	10.00	6X 2.40	0.50	56.30	1.504	1.050	.812E 02	.816E 02	0.152	0.587	1.616	.167E 01	.160E 01
	(ALD= 2.50,	FS= 2.42,		ETA= 1.00,		TI= 3.00)							
POL	10.00	2X 0.03	0.94	56.43	1.507	1.240	.764E 02	.769E 02	0.042	0.630	1.616	.157E 01	.150E 01
ROT	10.00	1X 0.00	0.90	0.00	1.673	2.100	.750E 02	.754E 02	0.039	0.669	1.616	.156E 01	.155E 01
POL	10.00	2X 0.03	0.94	56.43	1.507	1.240	.704E 02	.700E 02	0.039	0.700	1.616	.145E 01	.146E 01
DSC	10.00	6X 2.40	0.50	56.30	1.504	1.050	.307E 03	.314E 03	0.679	1.357	1.526	.604E 01	.610E 01
	(ALD= 2.50,	FS= 2.42,		ETA= 1.00,		TI= 3.00)							
LHS	10.00	1X 0.00	0.99	0.00	1.507	1.240	.304E 03	.311E 03	0.099	1.447	1.526	.598E 01	.604E 01
LHS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.301E 03	.300E 03	0.060	1.505	1.526	.263E 01	.266E 01
DSC	15.00	4X 3.00	3.40	56.30	1.504	1.050	.669E 03	.670E 03	0.674	2.123	1.475	.570E 01	.566E 01
	(ALD= 2.55,	FS= 2.42,		ETA= 1.00,		TI= 3.00)							
POL	15.00	1X 1.13	0.94	56.43	1.507	1.240	.629E 03	.637E 03	0.100	2.200	1.475	.536E 01	.532E 01
ROT	15.00	1X 1.10	0.90	0.00	1.673	2.100	.616E 03	.625E 03	0.103	2.365	1.475	.525E 01	.521E 01
POL	15.00	3X 1.10	0.94	56.43	1.507	1.240	.579E 03	.587E 03	0.092	2.447	1.475	.493E 01	.490E 01
LHS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.573E 03	.581E 03	0.111	2.552	1.475	.489E 01	.485E 01
LHS	20.00	1X 1.50	0.99	0.00	1.507	1.240	.568E 03	.575E 03	0.004	2.632	1.475	.272E 01	.270E 01
DSC	20.00	3X 3.20	3.20	56.30	1.504	1.050	.122E 04	.122E 04	0.552	3.120	1.431	.570E 01	.556E 01
	(ALD= 3.96,	FS= 2.42,		ETA= 1.00,		TI= 3.60)							
POL	20.00	1X 1.53	0.94	56.43	1.507	1.240	.115E 04	.115E 04	0.130	3.244	1.431	.544E 01	.523E 01
ROT	20.00	1X 1.50	0.90	0.00	1.673	2.100	.113E 04	.113E 04	0.253	3.498	1.431	.533E 01	.513E 01
POL	20.00	1X 1.53	0.94	56.43	1.507	1.240	.106E 04	.106E 04	0.127	3.565	1.431	.501E 01	.482E 01
LHS	20.00	1X 1.53	0.99	0.00	1.507	1.240	.105E 04	.105E 04	0.154	3.694	1.431	.496E 01	.477E 01

The performance can be improved somewhat by the use of uncoated input lenses to the spatial filters, and the interchange of disc and Faraday Rotator modules. Table VI summarizes this case for a saturation flux of 2.42 J/cm^2. One can now obtain 1300 Joules/beam with a maximum allowable backreflection of 65% (assuming a 5J/cm^2 damage threshold[9] at the AR coated Faraday rotator). Note, however, that the highest fluxes are still encountered on the same 10-15 cm spatial filter lens, so we have not removed the bottleneck.

Increasing the gain of the 15 cm disc amplifier from 3.4 to 4.88 will also improve the situation somewhat, as shown in Table VII for a 2.42 J/cm^2 saturation flux. The output increases to 1500 J/beam, and the bottlenecking is further reduced. If a saturation flux of 3.6 J/cm^2 is assumed (Table VIII), even less bottlenecking is evident, and an output of 1710J/beam is obtained. The allowable backreflection for these two cases is 60% and 45%, respectively.

To increase the output above this level, it is necessary to either increase the gain of the high energy section or decrease the losses in this section. One way to decrease the losses is to replace the uncoated spatial filter lenses with lenses fabricated of a phase separable glass such as Hoya ARG-2. Tables IX and X show the expected performance if this is done for saturation fluxes of 2.42 and 3.6 J/cm^2, respectively. Outputs of 1800J/beam and 2060J/beam were obtained for the two cases, and the allowable backreflections were 48% and 35%. Note, however, that moderately high fluxes were incident on the AR-coated Faraday Rotator glass; i.e., 4.51J/cm^2 and 5.12J/cm^2.

The alternate strategy (ie. increase of the gain) was examined by modeling the performance with an additional 20 cm amplifier. Table XI and Fig. 5

TABLE VI: NANOSECOND PERFORMANCE OF RECONFIGURED SYSTEM WITH UNCOATED INPUT LENSES

TE= 1.000 NL= 1.053

	[illegible]	THCK	[illegible]	ANGL	[illegible]	[illegible]	PMAX	EOUT	[illegible]	[illegible]	P78V	[illegible]	[illegible]
STS	5.00						.500E 01	.500E 01	0.000	0.000	1.484	.429E 00	.429E 00
ADD	5.00	1130.00	13.40	0.00	1.504	1.050	.300E 02	.392E 02	0.759	0.759	1.595	.310E 01	.310E 01
	(ALD= 0.93,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
POL	5.00	2X 0.00	0.94	56.43	1.507	1.240	.350E 02	.360E 02	0.079	0.837	1.595	.292E 01	.299E 01
POC	5.00	1X 7.00	0.96	0.00	1.500	1.000	.343E 02	.353E 02	0.333	1.160	1.595	.280E 01	.287E 01
POL	5.00	2X 0.00	0.94	56.43	1.507	1.240	.323E 02	.332E 02	0.071	1.238	1.595	.263E 01	.270E 01
LNS	5.00	1X 0.00	0.99	0.00	1.507	1.240	.319E 02	.329E 02	0.043	1.281	1.595	.260E 01	.267E 01
LNS	10.00	1X 0.00	0.99	0.00	1.507	1.240	.316E 02	.326E 02	0.011	1.291	1.595	.645E 00	.661E 00
DOC	10.00	6X 2.40	0.58	56.38	1.504	1.050	.103E 03	.107E 03	0.361	1.635	1.536	.362E 01	.365E 01
	(ALD= 2.50,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
POL	10.00	2X 0.00	0.94	56.43	1.507	1.240	.172E 03	.176E 03	0.092	1.719	1.536	.341E 01	.343E 01
ROT	10.00	1X 0.00	0.98	0.00	1.673	2.100	.168E 03	.172E 03	0.005	1.802	1.536	.324E 01	.323E 01
POL	10.00	2X 0.00	0.94	56.43	1.507	1.240	.150E 03	.162E 03	0.085	1.885	1.536	.314E 01	.316E 01
DOC	10.00	6X 2.40	0.58	56.38	1.504	1.050	.505E 03	.510E 03	1.203	2.942	1.436	.952E 01	.947E 01
	(ALD= 2.50,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
LNS	10.00	1X 0.00	0.93	0.00	1.451	0.950	.471E 03	.483E 03	0.121	3.045	1.436	.809E 01	.804E 01
LNS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.466E 03	.478E 03	0.009	3.122	1.436	.391E 01	.389E 01
POL	15.00	1X 1.10	0.94	56.43	1.507	1.240	.430E 03	.450E 03	0.060	3.180	1.436	.367E 01	.365E 01
ROT	15.00	1X 1.10	0.98	0.00	1.673	2.100	.430E 03	.441E 03	0.126	3.208	1.436	.360E 01	.358E 01
POL	15.00	1X 1.10	0.94	56.43	1.507	1.240	.404E 03	.414E 03	0.063	3.342	1.436	.339E 01	.337E 01
DOC	15.00	4X 3.00	3.40	56.38	1.504	1.050	.853E 03	.853E 03	0.849	4.003	1.390	.702E 01	.670E 01
	(ALD= 2.55,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
LNS	15.00	1X 1.10	0.93	0.00	1.451	0.950	.796E 03	.796E 03	0.122	4.094	1.390	.655E 01	.626E 01
LNS	20.00	1X 1.50	0.99	0.00	1.507	1.240	.780E 03	.780E 03	0.113	4.107	1.390	.365E 01	.360E 01
POL	20.00	1X 1.50	0.94	56.43	1.507	1.240	.741E 03	.740E 03	0.087	4.230	1.390	.343E 01	.337E 01
ROT	20.00	1X 1.50	0.98	0.00	1.673	2.100	.724E 03	.724E 03	0.160	4.391	1.390	.336E 01	.321E 01
POL	20.00	1X 1.50	0.94	56.43	1.507	1.240	.602E 03	.602E 03	0.000	4.457	1.390	.316E 01	.302E 01
DOC	20.00	3X 3.20	3.20	56.38	1.504	1.050	.149E 04	.149E 04	0.448	4.935	1.352	.668E 01	.603E 01
	(ALD= 3.96,	FS= 2.42,	ETA= 1.00,	TI= 3.50)									
LNS	20.00	1X 1.50	0.93	0.00	1.451	0.950	.135E 04	.131E 04	0.150	5.042	1.352	.623E 01	.563E 01

TABLE VII: EFFECT OF HIGHER GAIN 15cm AMPLIFIER

VE= 1.003 ML= 1.053

	APER	THCK	GLTH	ANGL	NO	N2	PMAX	EOUT	BTPK	BTMX	P/AV	INAX	FLUX
SSS	5.00						.500E 01	.500E 01	0.000	0.000	1.604	.429E 00	.429E 00
OSC	5.00	1X30.00	13.40	0.00	1.504	1.050	.388E 02	.392E 02	0.759	0.759	1.595	.318E 01	.318E 01
	(ALO= 0.43,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
POL	5.00	2X 0.00	0.96	56.43	1.507	1.240	.358E 02	.368E 02	0.079	0.837	1.595	.292E 01	.299E 01
POC	5.00	1X 7.00	0.96	0.00	1.500	1.000	.343E 02	.353E 02	0.333	1.160	1.595	.280E 01	.287E 01
POL	5.00	2X 0.00	0.96	56.43	1.507	1.240	.323E 02	.332E 02	0.071	1.230	1.595	.263E 01	.270E 01
LNS	5.00	1X 0.00	0.99	0.00	1.507	1.240	.319E 02	.329E 02	0.043	1.201	1.595	.260E 01	.267E 01
LNS	10.00	1X 0.00	0.99	0.00	1.507	1.240	.316E 02	.326E 02	0.011	1.291	1.595	.645E 00	.661E 00
OSC	10.00	6X 2.40	0.50	56.30	1.504	1.050	.103E 03	.107E 03	0.361	1.635	1.536	.362E 01	.365E 01
	(ALO= 2.50,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
POL	10.00	2X 0.00	0.96	56.43	1.507	1.240	.172E 03	.176E 03	0.092	1.719	1.536	.341E 01	.349E 01
ROT	10.00	1X 0.00	0.98	0.00	1.673	2.100	.168E 03	.172E 03	0.085	1.802	1.536	.334E 01	.331E 01
POL	10.00	2X 0.03	0.96	56.43	1.507	1.240	.158E 03	.162E 03	0.085	1.885	1.536	.314E 01	.316E 01
OSC	10.00	6X 2.40	0.50	56.30	1.504	1.050	.505E 03	.518E 03	1.203	2.942	1.436	.998E 01	.999E 01
	(ALO= 2.50,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
LNS	10.00	1X 0.00	0.93	0.00	1.451	0.950	.471E 03	.483E 03	0.121	3.045	1.436	.809E 01	.804E 01
LNS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.466E 03	.478E 03	0.089	3.122	1.436	.391E 01	.389E 01
POL	15.00	1X 1.10	0.96	56.43	1.507	1.240	.438E 03	.450E 03	0.068	3.180	1.436	.367E 01	.365E 01
ROT	15.00	1X 1.13	0.98	0.00	1.673	2.100	.430E 03	.441E 03	0.126	3.280	1.436	.360E 01	.350E 01
POL	15.00	1X 1.13	0.96	56.43	1.507	1.240	.404E 03	.414E 03	0.063	3.342	1.436	.339E 01	.337E 01
OSC	15.00	6X 3.00	6.00	56.30	1.504	1.050	.102E 04	.102E 04	0.947	4.097	1.375	.830E 01	.795E 01
	(ALO= 3.20,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
LNS	15.00	1X 1.10	0.93	0.00	1.451	0.950	.951E 03	.940E 03	0.146	4.170	1.375	.782E 01	.730E 01
LNS	20.00	1X 1.50	0.99	0.00	1.507	1.240	.941E 03	.930E 03	0.135	4.274	1.375	.436E 01	.411E 01
POL	20.00	1X 1.50	0.96	56.43	1.507	1.240	.885E 03	.882E 03	0.104	4.394	1.375	.410E 01	.386E 01
ROT	20.00	1X 1.50	0.98	0.00	1.673	2.100	.867E 03	.864E 03	0.191	4.502	1.375	.401E 01	.378E 01
POL	20.00	1X 1.50	0.96	56.43	1.507	1.240	.819E 03	.812E 03	0.096	4.576	1.379	.377E 01	.354E 01
OSC	20.00	3X 2.20	3.20	56.30	1.504	1.050	.166E 04	.166E 04	0.743	5.090	1.337	.759E 01	.688E 01
	(ALO= 3.96,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
LNS	20.00	1X 1.52	0.93	0.00	1.451	0.950	.155E 04	.149E 04	0.189	5.208	1.337	.708E 01	.639E 01

TABLE VIII: EFFECT OF HIGHER SATURATION FLUX

TC = 1.2[illegible] WL = 1.053

	SPED	TMLR	CLIM	ANGL	NO	N2	PMAX	POUT	RTRN	DTOT	P/AV	TRAN	FLUX
SEG	5.00						.250E 01	.250E 01	0.000	0.000	1.604	.214E 00	.214E 00
ROD	5.[illegible]	1830.0[illegible]	13.41	[illegible]	1.504	1.053	.250E 02	.259E 02	0.457	0.457	1.636	.215E 01	.216E 01
	(ALD= [illegible].43, FS= 3.60, ETA= 1.00, TI=000000)												
POL	5.[illegible]	2X 0.03	0.96	56.43	1.507	1.240	.242E 02	.243E 02	0.055	0.510	1.636	.202E 01	.203E 01
POC	5.[illegible]	1X 7.0[illegible]	[illegible].96	[illegible]	1.50[illegible]	1.003	.232E 02	.234E 02	0.231	0.741	1.636	.194E 01	.195E 01
POL	5.00	2X 0.0[illegible]	0.96	56.43	1.507	1.240	.219E 02	.220E 02	0.049	0.790	1.636	.182E 01	.183E 01
LOS	5.00	1X 0.0[illegible]	0.99	0.00	1.507	1.240	.216E 02	.217E 02	0.030	0.820	1.636	.181E 01	.181E 01
LOS	10.00	1X 0.0[illegible]	[illegible].99	[illegible]	1.507	1.240	.214E 02	.215E 02	0.007	0.828	1.636	.447E 00	.448E 00
OSC	10.[illegible]	6X 7.4[illegible]	9.50	56.40	1.504	1.050	.145E 03	.146E 03	0.276	1.103	1.597	.296E 01	.296E 01
	(ALD= 2.50, FS= 3.60, ETA= 1.00, TI=000000)												
POL	10.00	2X 0.0[illegible]	[illegible].96	56.43	1.507	1.240	.136E 03	.137E 03	0.075	1.178	1.597	.278E 01	.278E 01
ROT	10.[illegible]	1X [illegible]	[illegible].99	0.00	1.673	2.100	.133E 03	.134E 03	0.069	1.246	1.597	.273E 01	.273E 01
POL	10.[illegible]	2X [illegible]	[illegible].96	56.43	1.507	1.240	.125E 03	.126E 03	0.069	1.315	1.597	.256E 01	.257E 01
OSC	10.[illegible]	6X 2.4[illegible]	9.5[illegible]	56.38	1.504	1.050	.504E 03	.507E 03	1.139	2.391	1.501	.979E 01	.988E 01
	(ALD= 2.5[illegible], FS= 3.60, ETA= 1.00, TI=000000)												
LOS	10.00	1X 0.0[illegible]	[illegible].93	0.00	1.451	0.950	.470E 03	.473E 03	0.124	2.505	1.501	.914E 01	.903E 01
LOS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.466E 03	.468E 03	0.091	2.509	1.501	.402E 01	.397E 01
PSL	15.[illegible]	1X 1.1[illegible]	[illegible].96	56.43	1.507	1.240	.438E 03	.440E 03	0.379	2.654	1.501	.378E 01	.374E 01
ROT	15.00	1X 1.10	0.98	0.00	1.673	2.100	.429E 03	.431E 03	0.129	2.773	1.501	.370E 01	.366E 01
POL	15.00	1X 1.10	0.96	56.43	1.507	1.240	.403E 03	.405E 03	0.065	2.832	1.501	.348E 01	.344E 01
OSC	15.[illegible]	4X 3.0[illegible]	4.[illegible]	56.38	1.504	1.050	.112E 04	.110E 04	1.023	3.718	1.437	.949E 01	.859E 01
	(ALD= 3.[illegible], FS= 3.60, ETA= 1.00, TI=000000)												
LOS	15.00	1X 1.1[illegible]	[illegible].93	0.00	1.451	0.950	.105E 04	.103E 04	0.165	3.859	1.437	.886E 01	.836E 01
LOS	20.00	1X 1.[illegible]	[illegible].99	0.00	1.507	1.240	.104E 04	.102E 04	0.153	3.990	1.437	.493E 01	.466E 01
POL	20.00	1X 1.[illegible]	[illegible].96	56.43	1.507	1.240	.974E 03	.957E 03	0.118	4.091	1.437	.464E 01	.438E 01
ROT	20.00	1X 1.50	0.98	0.00	1.673	2.100	.954E 03	.938E 03	0.216	4.275	1.437	.454E 01	.429E 01
PSL	20.00	1X 1.53	0.96	56.43	1.507	1.240	.897E 03	.881E 03	0.109	4.368	1.437	.427E 01	.403E 01
OSC	20.00	4X 3.20	3.20	56.38	1.504	1.050	.191E 04	.183E 04	0.856	5.049	1.395	.900E 01	.812E 01
	(ALD= 3.96, FS= 3.60, ETA= 1.00, TI=000000)												
LOS	20.00	1X 1.[illegible]0	0.93	0.00	1.451	0.950	.178E 04	.171E 04	0.213	5.220	1.395	.839E 01	.757E 01

TABLE IX: RECONFIGURED SYSTEM WITH HIGHER GAIN 15cm AMPLIFIER AND ARG-2 LENSES

TE= 1.000 WL= 1.053

	APER	THCK	GLIN	ANGL	NO	N2	PMAX	EOUT	BIRX	ETPX	P/AV	IPPX	FLUX
SIG	5.00						.750E 01	.750E 01	0.000	0.000	1.684	.643E 00	.643E 00
ROD	5.00	1X30.00	13.40	0.00	1.504	1.050	.489E 02	.505E 02	1.023	1.023	1.577	.393E 01	.406E 01
	(ALD= 0.43, FS= 2.42, ETA= 1.00, T1= 3.00)												
POL	5.00	2X 0.80	0.94	56.43	1.507	1.240	.460E 02	.475E 02	0.100	1.120	1.577	.369E 01	.381E 01
PBC	5.00	1X 7.00	0.96	0.00	1.500	1.000	.441E 02	.456E 02	0.422	1.530	1.577	.355E 01	.366E 01
POL	5.00	2X 0.80	0.94	56.43	1.507	1.240	.415E 02	.429E 02	0.090	1.617	1.577	.333E 01	.344E 01
LNS	5.00	1X 0.80	0.99	0.00	1.507	1.240	.411E 02	.424E 02	0.055	1.670	1.577	.330E 01	.341E 01
LNS	10.00	1X 0.80	0.99	0.00	1.507	1.240	.407E 02	.420E 02	0.014	1.683	1.577	.816E 00	.844E 00
OSC	10.00	6X 2.40	8.50	56.38	1.504	1.050	.219E 03	.224E 03	0.439	2.109	1.511	.424E 01	.432E 01
	(ALD= 2.50, FS= 2.42, ETA= 1.00, T1= 3.00)												
POL	10.00	2X 0.80	0.94	56.43	1.507	1.240	.206E 03	.211E 03	0.108	2.211	1.511	.399E 01	.406E 01
ROT	10.00	1X 0.80	0.98	0.00	1.673	2.100	.202E 03	.207E 03	0.099	2.304	1.511	.391E 01	.398E 01
POL	10.00	2X 0.80	0.94	56.43	1.507	1.240	.190E 03	.194E 03	0.099	2.398	1.511	.367E 01	.374E 01
OSC	10.00	6X 2.40	8.50	56.38	1.504	1.050	.560E 03	.577E 03	1.359	3.555	1.412	.105E 02	.104E 02
	(ALD= 2.50, FS= 2.42, ETA= 1.00, T1= 3.00)												
LNS	10.00	1X 0.80	0.99	0.00	1.507	1.240	.555E 03	.571E 03	0.172	3.689	1.412	.104E 02	.103E 02
LNS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.549E 03	.565E 03	0.104	3.771	1.412	.458E 01	.452E 01
POL	15.00	1X 1.10	0.94	56.43	1.507	1.240	.516E 03	.531E 03	0.080	3.833	1.412	.431E 01	.424E 01
ROT	15.00	1X 1.10	0.98	0.00	1.673	2.100	.506E 03	.521E 03	0.147	3.948	1.412	.422E 01	.416E 01
POL	15.00	1X 1.10	0.94	56.43	1.507	1.240	.475E 03	.489E 03	0.074	4.006	1.412	.397E 01	.391E 01
OSC	15.00	4X 3.00	4.88	56.38	1.504	1.050	.115E 04	.114E 04	1.072	4.807	1.352	.933E 01	.870E 01
	(ALD= 3.28, FS= 2.42, ETA= 1.00, T1= 3.00)												
LNS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.114E 04	.113E 04	0.210	4.950	1.352	.924E 01	.861E 01
LNS	20.00	1X 1.50	0.99	0.00	1.507	1.240	.112E 04	.111E 04	0.159	5.060	1.352	.514E 01	.479E 01
POL	20.00	1X 1.50	0.94	56.43	1.507	1.240	.106E 04	.105E 04	0.123	5.143	1.352	.483E 01	.451E 01
ROT	20.00	1X 1.50	0.98	0.00	1.673	2.100	.104E 04	.103E 04	0.225	5.297	1.352	.474E 01	.442E 01
POL	20.00	1X 1.50	0.94	56.43	1.507	1.240	.974E 03	.965E 03	0.113	5.375	1.352	.445E 01	.415E 01
OSC	20.00	3X 3.20	3.20	56.38	1.504	1.050	.190E 04	.182E 04	0.861	5.900	1.314	.864E 01	.740E 01
	(ALD= 3.96, FS= 2.42, ETA= 1.00, T1= 3.00)												
LNS	20.00	1X 1.50	0.99	0.00	1.507	1.240	.180E 04	.100E 04	0.265	6.152	1.314	.856E 01	.752E 01

TABLE X: EFFECT OF HIGHER SATURATION FLUX

TE= 1.000 WL= 1.053

	APER	THCK	GAIN	ANGL	N0	N2	PMAX	EOUT	BTHX	ETHX	P/AV	IPAX	FLUX
STG	5.00						.330E 01	.330E 01	0.000	0.000	1.604	.203E 00	.203E 00
ROD	5.00	1X30.00	13.40	0.00	1.504	1.050	.320E 02	.321E 02	0.579	0.579	1.626	.265E 01	.266E 01
	(ALD= 0.43,	FS= 3.60,		ETA= 1.00,		TI=00000)							
POL	5.00	2X 0.80	0.94	56.43	1.507	1.240	.300E 02	.302E 02	0.067	0.647	1.626	.249E 01	.250E 01
PUC	5.00	1X 7.00	0.96	0.00	1.500	1.000	.288E 02	.290E 02	0.285	0.931	1.626	.239E 01	.240E 01
POL	5.00	2X 0.80	0.94	56.43	1.507	1.240	.271E 02	.272E 02	0.061	0.992	1.626	.225E 01	.226E 01
LNS	5.00	1X 0.80	0.99	0.00	1.507	1.240	.268E 02	.270E 02	0.037	1.029	1.626	.222E 01	.223E 01
LNS	10.00	1X 0.80	0.99	0.00	1.507	1.240	.266E 02	.267E 02	0.009	1.038	1.626	.551E 00	.553E 00
DSC	10.00	6X 2.40	0.50	56.38	1.504	1.050	.173E 03	.173E 03	0.329	1.367	1.581	.351E 01	.349E 01
	(ALD= 2.50,	FS= 3.60,		ETA= 1.00,		TI=00000)							
POL	10.00	2X 0.80	0.94	56.43	1.507	1.240	.163E 03	.163E 03	0.089	1.454	1.581	.330E 01	.328E 01
ROT	10.00	1X 0.80	0.98	0.00	1.673	2.100	.159E 03	.160E 03	0.082	1.536	1.581	.323E 01	.321E 01
POL	10.00	2X 0.80	0.94	56.43	1.507	1.240	.158E 03	.158E 03	0.082	1.614	1.581	.304E 01	.302E 01
DSC	10.00	6X 2.40	0.50	56.38	1.504	1.050	.561E 03	.563E 03	1.291	2.016	1.482	.108E 02	.106E 02
	(ALD= 2.50,	FS= 3.60,		ETA= 1.00,		TI=00000)							
LNS	10.00	1X 0.80	0.99	0.00	1.507	1.240	.556E 03	.557E 03	0.178	2.911	1.482	.107E 02	.105E 02
LNS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.550E 03	.551E 03	0.107	3.065	1.482	.472E 01	.463E 01
POL	15.00	1X 1.10	0.94	56.43	1.507	1.240	.517E 03	.518E 03	0.083	3.137	1.482	.444E 01	.435E 01
ROT	15.00	1X 1.10	0.98	0.00	1.673	2.100	.507E 03	.508E 03	0.152	3.270	1.482	.435E 01	.426E 01
POL	15.00	1X 1.10	0.94	56.43	1.507	1.240	.476E 03	.478E 03	0.076	3.336	1.482	.409E 01	.401E 01
DSC	15.00	4X 3.00	4.80	56.38	1.504	1.050	.126E 04	.123E 04	1.172	4.337	1.417	.105E 02	.980E 01
	(ALD= 3.20,	FS= 3.60,		ETA= 1.00,		TI=00000)							
LNS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.125E 04	.122E 04	0.236	4.526	1.417	.104E 02	.970E 01
LNS	20.00	1X 1.50	0.99	0.00	1.507	1.240	.124E 04	.121E 04	0.180	4.669	1.417	.579E 01	.545E 01
POL	20.00	1X 1.50	0.94	56.43	1.507	1.240	.116E 04	.114E 04	0.130	4.780	1.417	.544E 01	.512E 01
ROT	20.00	1X 1.50	0.98	0.00	1.673	2.100	.114E 04	.111E 04	0.254	4.982	1.417	.534E 01	.502E 01
POL	20.00	1X 1.50	0.94	56.43	1.507	1.240	.107E 04	.105E 04	0.127	5.084	1.417	.501E 01	.472E 01
DSC	20.00	3X 3.20	3.20	56.38	1.504	1.050	.219E 04	.208E 04	0.995	5.905	1.375	.101E 02	.989E 01
	(ALD= 3.96,	FS= 3.60,		ETA= 1.00,		TI=00000)							
LNS	20.00	1X 1.50	0.99	0.00	1.507	1.240	.217E 04	.206E 04	0.311	6.145	1.375	.100E 02	.900E 01

TABLE XI: RECONFIGURED SYSTEM WITH HIGHER GAIN 15cm AMPLIFIER, UNCOATED INPUT LENSES, AND AN ADDITIONAL 20cm AMPLIFIER

TE= 1.003 WL= 1.053

	APER	THCK	GLIN	ANGL	NO	N2	PMAX	EOUT	BIRX	ETRX	P/AV	IRRX	FLUX
SIG	5.00						.500E 01	.500E 01	0.000	0.000	1.684	.429E 00	.429E 00
ROD	5.00	1X30.00	13.40	0.00	1.504	1.050	.380E 02	.392E 02	0.759	0.759	1.595	.310E 01	.318E 01
	(ALD= 0.43,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
POL	5.00	2X 0.80	0.94	56.43	1.507	1.240	.358E 02	.368E 02	0.079	0.837	1.595	.292E 01	.295E 01
POC	5.00	1X 7.00	0.96	0.00	1.500	1.000	.343E 02	.353E 02	0.333	1.168	1.595	.280E 01	.287E 01
POL	5.00	2X 0.80	0.94	56.43	1.507	1.240	.323E 02	.332E 02	0.071	1.238	1.595	.263E 01	.270E 01
LNS	5.00	1X 0.80	0.99	0.00	1.507	1.240	.319E 02	.329E 02	0.043	1.281	1.595	.260E 01	.267E 01
LNS	10.00	1X 0.80	0.99	0.00	1.507	1.240	.316E 02	.326E 02	0.011	1.291	1.595	.645E 00	.641E 00
OSC	10.00	6X 2.40	0.50	56.38	1.504	1.050	.183E 03	.187E 03	0.361	1.635	1.536	.362E 01	.365E 01
	(ALD= 2.50,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
POL	10.00	2X 0.80	0.94	56.43	1.507	1.240	.172E 03	.176E 03	0.092	1.719	1.536	.341E 01	.343E 01
ROT	10.00	1X 0.80	0.98	0.00	1.673	2.100	.168E 03	.172E 03	0.085	1.802	1.536	.334E 01	.337E 01
POL	10.00	2X 0.80	0.94	56.43	1.507	1.240	.158E 03	.162E 03	0.085	1.805	1.536	.314E 01	.314E 01
OSC	10.00	6X 2.40	0.50	56.38	1.504	1.050	.505E 03	.518E 03	1.203	2.942	1.436	.952E 01	.947E 01
	(ALD= 2.56,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
LNS	10.00	1X 0.80	0.93	0.00	1.451	0.950	.471E 03	.483E 03	0.121	3.045	1.436	.889E 01	.884E 01
LNS	15.00	1X 1.10	0.99	0.00	1.507	1.240	.466E 03	.478E 03	0.089	3.122	1.436	.391E 01	.389E 01
POL	15.00	1X 1.10	0.94	56.43	1.507	1.240	.430E 03	.450E 03	0.068	3.180	1.436	.367E 01	.365E 01
ROT	15.00	1X 1.10	0.98	0.00	1.673	2.100	.430E 03	.441E 03	0.126	3.288	1.436	.360E 01	.358E 01
POL	15.00	1X 1.10	0.94	56.43	1.507	1.240	.404E 03	.414E 03	0.063	3.342	1.436	.339E 01	.337E 01
OSC	15.00	4X 3.00	4.80	56.38	1.504	1.050	.102E 04	.102E 04	0.947	4.057	1.375	.838E 01	.791E 01
	(ALD= 3.28,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
LNS	15.00	1X 1.10	0.93	0.00	1.451	0.950	.951E 03	.948E 03	0.146	4.170	1.375	.782E 01	.730E 01
LNS	20.00	1X 1.50	0.99	0.00	1.507	1.240	.941E 03	.938E 03	0.135	4.274	1.375	.436E 01	.411E 01
POL	20.00	1X 1.50	0.94	56.43	1.507	1.240	.885E 03	.882E 03	0.104	4.354	1.375	.410E 01	.386E 01
ROT	20.00	1X 1.50	0.98	0.00	1.673	2.100	.867E 03	.864E 03	0.191	4.502	1.375	.401E 01	.370E 01
POL	20.00	1X 1.50	0.94	56.43	1.507	1.240	.815E 03	.812E 03	0.096	4.576	1.375	.377E 01	.356E 01
OSC	20.00	3X 3.20	3.20	56.38	1.504	1.050	.166E 04	.160E 04	0.743	5.090	1.337	.759E 01	.680E 01
	(ALD= 3.96,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
OSC	20.00	3X 3.20	3.20	56.38	1.504	1.050	.275E 04	.261E 04	1.334	5.955	1.298	.125E 02	.108E 02
	(ALD= 3.96,	FS= 2.42,	ETA= 1.00,	TI= 3.00)									
LNS	20.00	1X 1.50	0.93	0.00	1.451	0.950	.257E 04	.244E 04	0.296	6.129	1.290	.117E 02	.101E 02

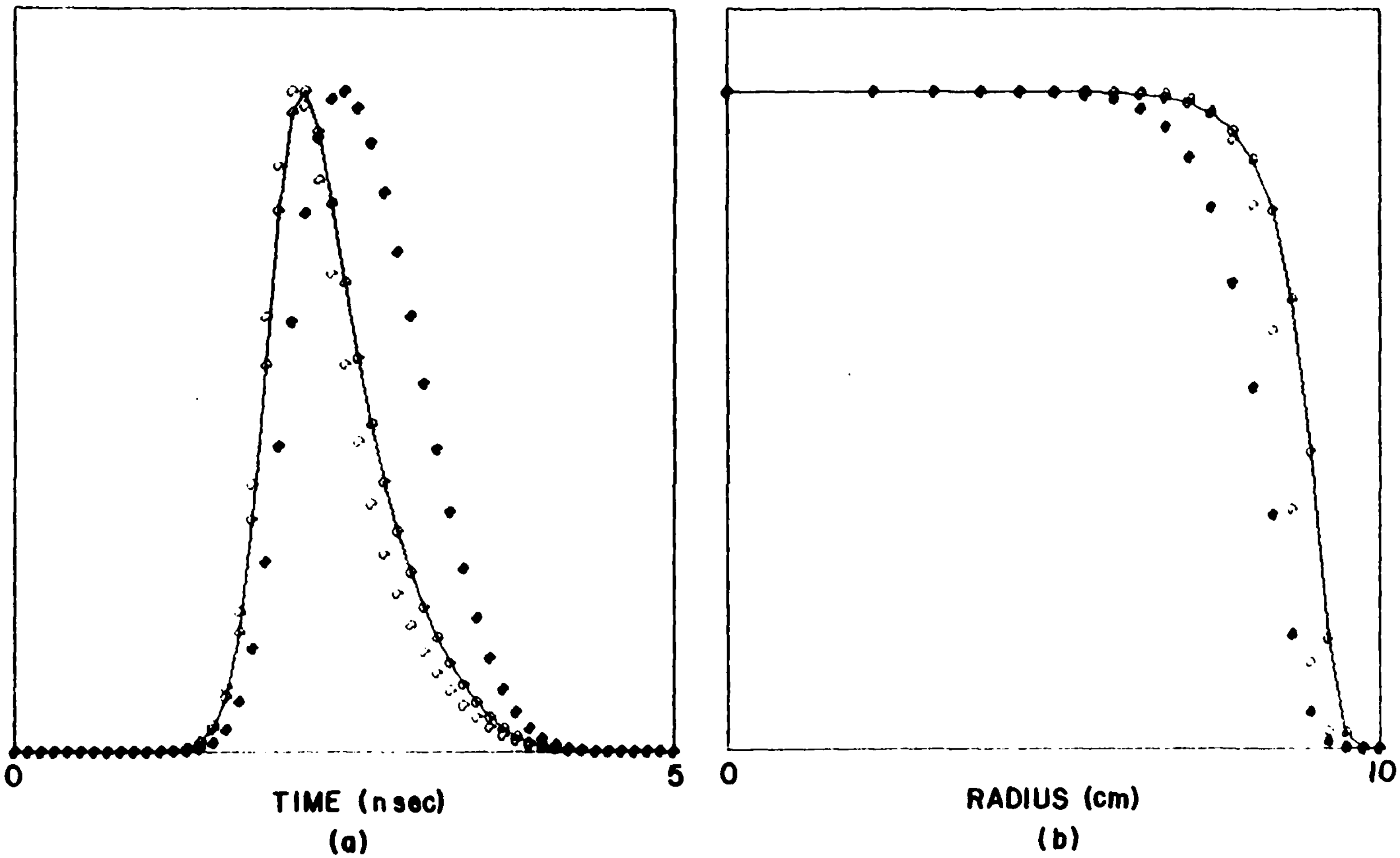

Fig. 5 — Temporal (5a) and spatial (5b) profiles at the output of the system described in Table XI with a nanosecond input pulse. The curves have the same meaning as those in Figs. (3a, b).

show the results for a case where this was done using uncoated spatial filter input lenses and a saturation flux of 2.42 J/cm^2. An output of 2500 Joules/beam was obtained from the laser at the same total B integral as found in the previous cases at 1800 and 2060 J/beam outputs; moreover, the flux on the Faraday Rotator was reduced to 3.86 J/cm^2. The allowable backreflection in this configuration was 25%. With a higher saturation flux or ARG-2 lenses, the output energy would not increase because the output lens is now the weak link; however, these expedients could be used to reduce the B integral and the flux on earlier components to slightly lower values.

6. Summary

The GEKKO XII-Module phosphate laser system appears capable in the reported configuration of substantially exceeding the Shiva performance. In fact, it appears that it would closely match the per beam performance of Argus (2.5 TW short pulse, 1000J in a nanosecond pulse) with much lower cost because of the smaller number of amplifiers.

The reported configuration, however, does not appear to represent the most cost effective strategy for either short or long pulses. A different configuration of the same elements and a different type of input spatial filter lens appears capable of increasing the output by at least 50%. Adding an additional twenty centimeter amplifier to each arm appears to be a relatively cost effective strategy for boosting the output in nanosecond pulses to 2.5 kJ per beam. Although these designs would provide adequate isolation for most single beam experiments, they would probably have to be supplemented by plasma shutters[9] at the outputs in multi beam configurations, where backreflection could be a serious problem.

If Shiva were retrofitted with phosphate glass, it should be capable of 35kJ or more with the present amplifiers, and 50kJ with an additional 20cm phosphate disc amplifier per beam.

7. Acknowledgments

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References

1. Y. Kato, S. Nakai and C. Yamanaka, Proceedings of the IAEA Technical Committee on Advances in Inertial Confinement Systems; ed. by C. Yamanaka (Institute of Laser Engineering, Osaka University, 1980) p. 59

2. C. Yamanaka, Topical Meeting on Inertial Confinement Fusion (San Diego, CA, 26-28 February, 1980) paper TUA3.

3. Y. Kato, K. Yoshida, J. Kuroda and C. Yamanaka, Appl. Phys. Lett (in print).

4. Laser Program Annual Report - 1978, Lawrence Livermore Laboratory UCRL-50021-78 (Vol. 1, Sec. 2).

5. Y. Kato, private communication.

6. J.M. McMahon, R.H. Lehmberg and S.E. Bodner, Technical Digest: Inertial Confinement Fusion, published by Optical Society of America, Paper TuB3-1 (1978).

7. P.V. Avizones and R.L. Grotbeck, J. Appl. Phys. **37**, 687 (1966).

8. This value was obtained from the expression $h\nu/2\sigma$ and the measured LGH-7 cross section $\sigma = 3.9 \times 10^{-20}$ cm^2. (S.E. Stokowski, R.A. Saroyan and M.J. Weber; Nd-Doped Laser Glass Spectroscopic and Physical Properties, Lawrence Livermore Laboratory report prepared for USDOE under contract No. W-7405-Eng-48; November 1978). For a pulsewidth of 1 nsec and a lower level relaxation time T_1 = 3 nsec, the effective saturation flux is approximately 2.6 J/cm^2.

9. Laser Program Annual Report-1979, Lawrence Livermore National Laboratory UCRL-50021-79 (Vol. 1, Sec. 2)

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